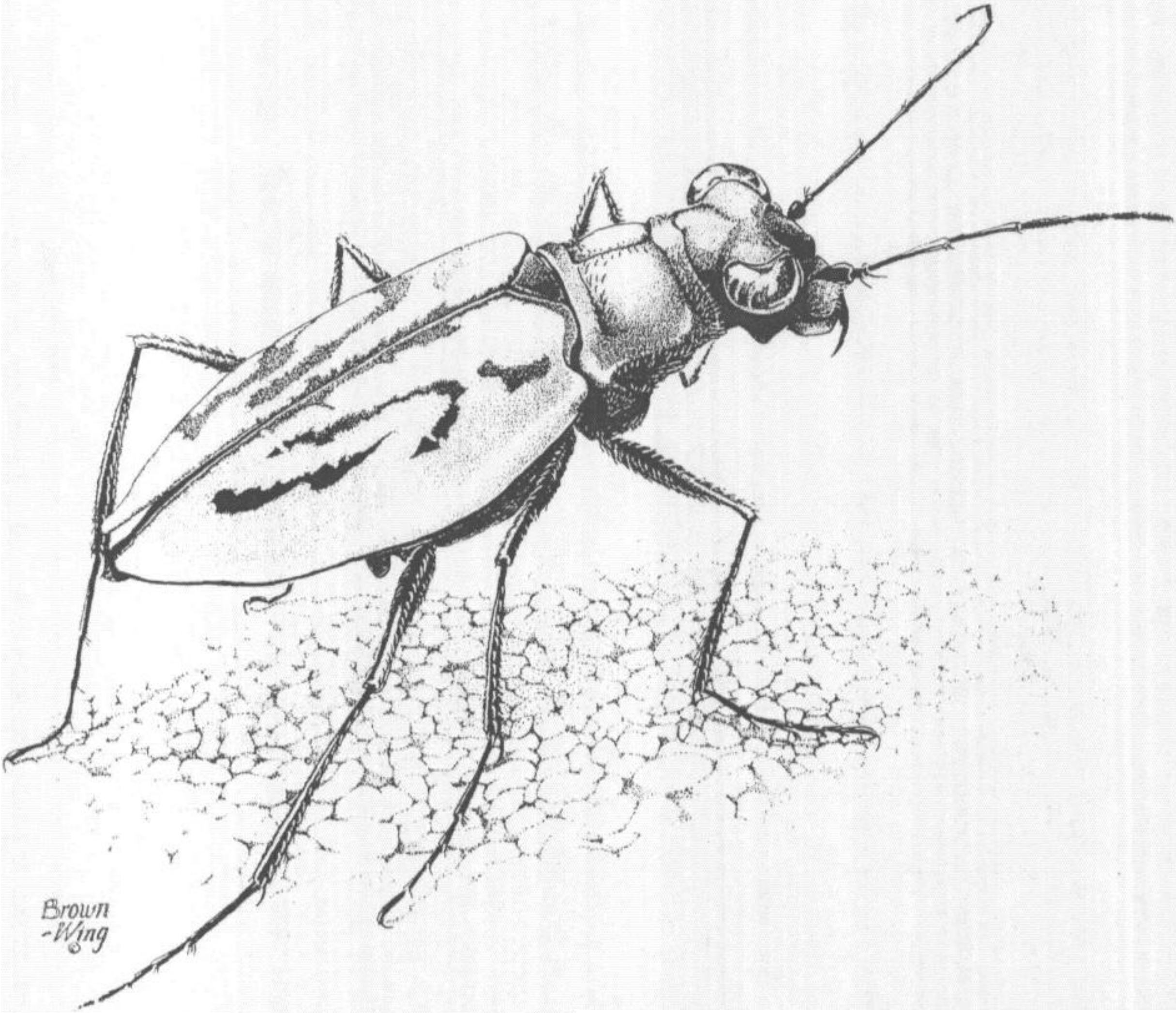
Northeastern Beach Tiger Beetle
(*Cincindela dorsalis dorsalis* Say)



RECOVERY PLAN

U.S. Fish and Wildlife Service
Hadley, Massachusetts

September 1994

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Katherine Brown-Wing

NORTHEASTERN BEACH TIGER BEETLE

(*Cicindela dorsalis dorsalis* Say)

RECOVERY PLAN

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Date: 9-29-94

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EXECUTIVE SUMMARY
NORTHEASTERN BEACH TIGER BEETLE RECOVERY PLAN

Current Status: This tiger beetle occurred historically "in great swarms" on beaches along the Atlantic Coast, from Cape Cod to central New Jersey, and along Chesapeake Bay beaches in Maryland and Virginia. Currently, only two small populations remain on the Atlantic Coast. The subspecies occurs at over 50 sites within the Chesapeake Bay region. Approximately 16 of these sites support more than 500 adults, and 10 sites support from 100 to 500 adults. *Cicindela dorsalis dorsalis* was listed as threatened in August of 1990.

Limiting Factors: *Cicindela dorsalis dorsalis* is most vulnerable to disturbance in the larval stage, which lasts two years. Larvae live in vertical burrows generally in the beach intertidal zone, where they are particularly sensitive to destruction by high levels of pedestrian traffic, ORVs, and other factors such as beach changes due to coastal development and beach stabilization structures. Although dispersal abilities of adults are good, population recruitment seems to be hampered by a lack of both undisturbed beaches and of nearby populations as a colonizing source.

Recovery Objective: To delist the northeastern beach tiger beetle.

Recovery Criteria: The species can be removed from threatened status when:

1. At least three viable populations have been established and permanently protected in each of four designated Geographic Recovery Areas covering the subspecies' historical range in the Northeast, with each GRA having one or more sites with large populations (peak count $\geq$ 500 adults) and sufficient protected habitat for expansion and genetic interchange.
2. At least 26 viable populations distributed throughout all five Chesapeake Bay GRAs are permanently protected.
3. Life history parameters (including population genetics and taxonomy), human impacts, and factors causing decline are understood well enough to provide needed protection and management.
4. An established, long-term management program exists in all states where the species occurs or is reintroduced.

Actions Needed:

1. Monitor known populations and any additional populations that are discovered.
2. Determine population and habitat viability.
3. Protect viable populations and their habitat.
4. Study life history parameters.
5. Evaluate human impacts.
6. Implement management measures at natural population sites.
7. Develop captive rearing techniques and conduct reintroductions.
8. Implement educational activities.

Projected Costs ($000):

YEAR	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Need 7	Need 8	Total
FY1	23.0	4.0	18.0	25.0	5.0		6.5	4.0	85.5
FY2	23.0		12.5	19.0	5.0		6.5	2.5	68.5
FY3	21.0		12.5	15.0	10.5		8.5	1.5	69.0
FY4-11	88.0	___	25.0	___	10.0	80.0	28.0	12.0	233.0
OTAL	155.0	4.0	68.0	59.0	30.5	80	49.5	20.0	476.0

Note: Needs 1, 3, and 6 will require continued funding following delisting.

DELISTING MAY BE INITIATED IN 2005 (depending on fate of repatriation sites).

*   *   *

The following recovery plan delineates a practical course of action for protecting and recovering the threatened northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*). Attainment of recovery objectives and availability of funds will be subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

This recovery plan has been prepared through the joint efforts of private consultants and the U.S. Fish and Wildlife Service, in cooperation with members of the Tiger Beetle Recovery Planning Group. The plan does not, however, necessarily represent the views or official position of any individuals or agencies other than the U.S. Fish and Wildlife Service. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1994. Northeastern Beach Tiger Beetle (*Cicindela dorsalis dorsalis* Say) Recovery Plan. Hadley, Massachusetts. 60 pp.

Additional copies of this plan can be purchased from:

Fish and Wildlife Reference Service
5430 Grosvenor lane, Suite 110
Bethesda, Maryland 20814
301-492-6403
or
1-800-582-3421

Cost varies according to number of pages.

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PART I: INTRODUCTION

Tiger beetles are an interesting and ecologically important group of insects. They are typically the dominant invertebrate predators in many habitats where they occur -- open sand flats, dunes, water edges, beaches, woodland paths, and sparse grassy areas. These insects have become important models for testing ecological theories about community structure (Pearson 1986), competition (Pearson and Mury 1979), food limitation (Knisley and Pearson 1981, Pearson and Knisley 1985, Knisley and Juliano 1988), thermoregulation (Pearson and Lederhouse 1987, Dreisig 1985, Knisley *et al.* 1990), and predator defense (Schultz 1986). The diversity of the family Cicindelidae is exhibited by the fact that nearly 100 species and over 100 subspecies and color forms are represented in the United States alone (Boyd 1982). Worldwide, some 2,028 species have been described, and the taxon is considered to be an excellent indicator of regional patterns of biodiversity (Pearson and Cassola 1992). This diversity has contributed to the great popularity of these insects among amateurs and professionals, as exemplified by the journal *Cicindela*, published since 1969, which is devoted entirely to tiger beetles.

The species *Cicindela dorsalis* is an indicator of a healthy beach community, as are other rare beach-dwellers such as the piping plover (*Charadrius melodus*) and sea beach amaranth (*Amaranthus pumilis*). The presence or absence of such rare, habitat-specific organisms can often help differentiate a healthy wild beach from degraded beach conditions. The beach ecosystem conducive to C. dorsalis survival is undisturbed by heavy human use, highly dynamic, and subject to natural erosion and accretion processes. This type of beach habitat, along with its associated species, has been seriously reduced along much of the Atlantic and Gulf coasts of the United States, and particularly so in the Northeast as a result of intense coastal development, shoreline stabilization, recreational use, and possibly other causes.

Cicindela dorsalis has a coastal distribution with four currently recognized subspecies ranging from New England to south Texas (Boyd and Rust 1982). The subspecies *Cicindela dorsalis dorsalis* ranges along the Atlantic Coast from Cape Cod south to central New Jersey and along both shores of the Chesapeake Bay in Maryland and Virginia. The range of *C. d. media* extends from southern New Jersey to Miami, Florida. *C. d. saulyci* ranges from the Florida gulf coast west to Mississippi, and *C. d. venusta* occurs from Louisiana to south Texas. All subspecies seem to have experienced extirpation from some sites, but *C. d. dorsalis* along the Atlantic Coast has experienced the most significant decline in range and populations (Knisley *et al.* 1987).

Cicindela dorsalis dorsalis is currently known from only two sites along the Atlantic Coast, both in Massachusetts; it remains relatively well established in the Chesapeake Bay area. Due to a greatly reduced range and an apparently high susceptibility to natural and human-related threats, this beetle has been listed as a Federally threatened species (U.S. Fish and Wildlife Service 1990). The species, including the related subspecies *C. d. media*, is also listed as endangered by Maryland (Hill 1988). Massachusetts lists *C. d. dorsalis* as endangered, and threatened status has been proposed in Virginia.

POPULATION STATUS AND DISTRIBUTION

Cicindela dorsalis dorsalis was once described as occurring in "great swarms" along beaches from Martha's Vineyard to New Jersey (Leng 1902) and as "very abundant on open, sandy beaches of the Atlantic coast of the middle and northern states" (LeConte 1857) (Figures 1 and 2). By the 1950s, however, most of the northeastern populations had disappeared (Knisley *et al.* 1987). Except for two populations in southeastern Massachusetts, the species has been extirpated from all of Massachusetts, Rhode Island, Connecticut, New York (Long Island), and New Jersey.

Potential habitat for the beetles still exists at some of the historical sites along the Atlantic Coast (Table 1). Surveys conducted in 1993 for *Cicindela dorsalis dorsalis* and *C. d. media* in New Jersey

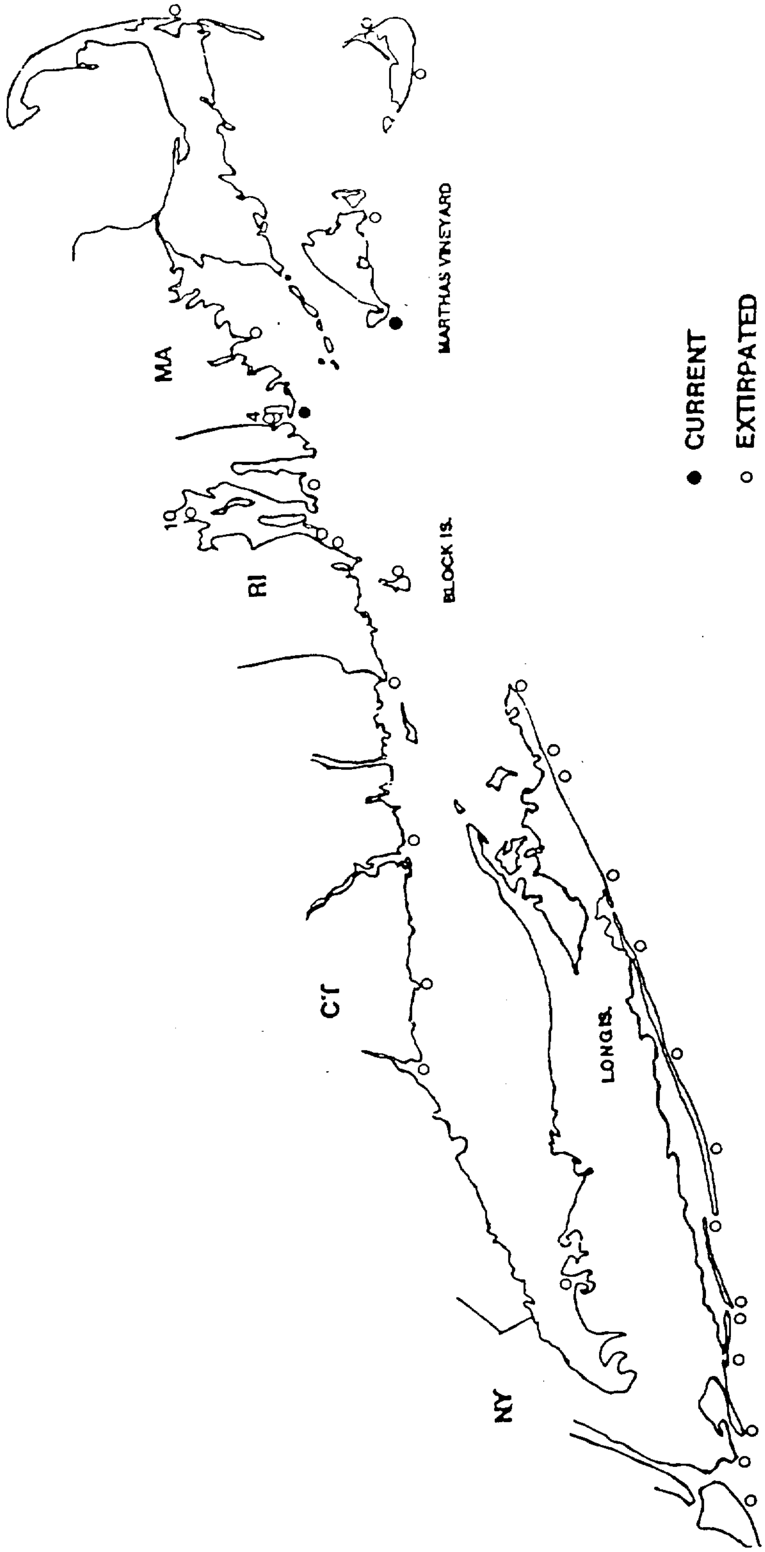

Figure 1. Location of extant and extirpated populations of *Cicindela dorsalis dorsalis* in New England and New York

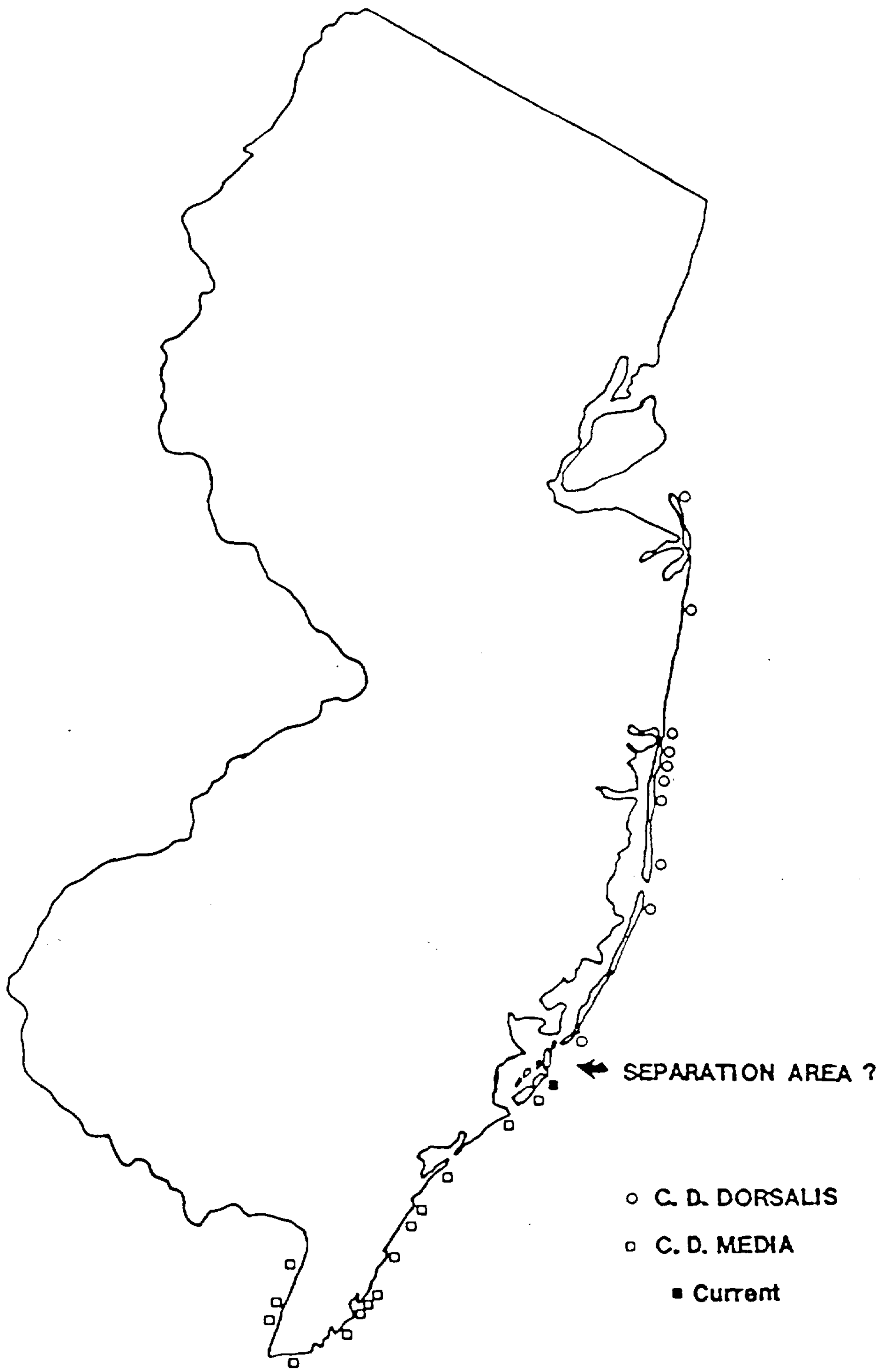

Figure 2. Location of *Cicindela dorsalis dorsalis* and *C. d. media* in New Jersey

Table 1. *Cicindela dorsalis dorsalis* sites (historic and extant) in New England, New York, and New Jersey.

SITE	TOWN	COUNTY	STATUS*
Massachusetts			
Martha's Vineyard	Martha's Vineyard	Dukes	Extant
Westport area		Bristol	Extant
Coast Guard Beach	Eastham	Barnstable	Med-hi restoration potential
Fall River area		Barnstable	Low restoration potential
South Beach Island	Chatham	Barnstable	Med-hi restoration potential
Westport Point	Westport	Bristol	Low restoration potential
Nantucket	Wauwinet	Nantucket	Low restoration potential
Rhode Island			
Napatree Point	Watch Hill		Low-med restoration potential
Block Island site	Block Island	Washington	Low restoration potential
Narrangansett Pier	?	Washington	Low-no restoration potential
Roger Williams Park	Providence	Washington	Low-no restoration potential
Newport	—	Newport	Low-no restoration potential
Connecticut			
Sandy Point	West Haven	New Haven	Low-med restoration potential
Fenwick Point	Old Saybrook	New Haven	Med restoration potential
Griswold Point	Lyme	New Haven	Med restoration potential
Lighthouse Point	East Haven	New Haven	Low-no restoration potential
Hammonaset	Clinton	New Haven	Low-no restoration potential
New York			
Montauk Point (Montauk)	East Hampton	Suffolk	Low-no restoration potential
Napeague Beach (Napeague)	East Hampton	Suffolk	Low-no restoration potential
Amagansett	East Hampton	Suffolk	Low-no restoration potential
Southampton	Southampton	Suffolk	Low-no restoration potential
Quogue	Southampton	Suffolk	Low-no restoration potential
Bellport	Brookhaven	Suffolk	Low-no restoration potential
Fire Island Beach	Brookhaven or Islip	Suffolk	Med restoration potential
Gilgo	Babylon	Suffolk	Low-no restoration potential
Cold Spring Harbor	Huntington	Suffolk	Low-no restoration potential
Jones Beach	Hempstead	Nassau	Low-no restoration potential
Lido Beach	Hempstead	Nassau	Low-no restoration potential
Long Beach	Hempstead	Nassau	Low-no restoration potential
Rockaway	?	Queens	Low restoration potential
Coney Island	?	Kings (Brooklyn)	Low-no restoration potential
Staten Island	?	Richmond	Low-no restoration potential
New Jersey			
Gateway NRA	Fort Hancock	Monmouth	High restoration potential
Asbury Park	Asbury Park	Monmouth	Low restoration potential
Manasquan	Manasquan	Monmouth	Low restoration potential
Island Beach State Park	Berkeley	Ocean	Med restoration potential
Forsythe NWR	Long Beach	Ocean	Med restoration potential
Point Pleasant	Pt. Pleasant Beach	Ocean	Low restoration potential
Mantoloking	Mantoloking	Ocean	Low restoration potential

* Restoration potential based on preliminary assessments; subject to change. Note that sites with conservation potential within the species' range are not necessarily confined to historic sites. See Conservation Measures, Habitat Protection and Management.

Table 2. Key Chesapeake Bay *C. d. dorsalis* sites.

VIRGINIA SITES			MARYLAND SITES
Bavon	Hyslop Marsh	Savage Neck Dunes	Cove Point
Bethel Beach	Jarvis Point	Scarborough Neck	Flag Ponds
Cape Charles South	Kiptopeke State Park	Silver Beach	Scientists Cliffs
Dameron Marsh	New Point Comfort	Smith Point	Western Shores Estates
Grandview Beach	Parkers Marsh	Taskmakers Creek	Cedar Island
Gwynn Island	Picketts Harbor	Vir-Mar Beach	Janes Island
Haynie Point	Rigby Island	Winter Harbor	
Hughlett Point	Sandy Point Island		

examined sites with some natural or semi-natural habitat remaining and assessed their suitability as reintroduction sites. No *C. d. dorsalis* were found at any of these New Jersey sites, but three historic sites were found to have suitable conditions for reintroduction of this taxon (Hill and Knisley 1994).

The Chesapeake Bay region was once thought to have few *C. d. dorsalis* populations (Boyd 1975, Glaser 1976), but recent survey efforts indicate otherwise: Between 1989 and 1992 the species was found at 55 sites in Virginia (Buhlmann and Pague 1992), and between 1988 and 1993 the beetles were found at 13 sites in Calvert County, Maryland (Figure 3). This includes 16 occurrences with over 500 adults (defined as "large" populations), 10 sites with 100-500 adults, and numerous additional sites with fewer than 100 adults (Knisley 1987a, Knisley *et al.* 1987, Knisley and Hill 1989, Hill and Knisley 1991, Buhlmann and Pague 1992, Donoff *et al.* 1994), Maryland Natural Heritage Program 1994) (Figure 3). Significant Chesapeake Bay sites, based on a consistent population size of > 200 *C. d. dorsalis* and/or conservation potential (C.B. Knisley, Randolph-Macon College, *in litt.* 1993), are indicated in Table 2.

Despite an increase in the number of known populations in the Chesapeake Bay area, *C. d. dorsalis* is by no means secure. Few sites are protected, and many are threatened by human impacts such as habitat alteration and recreational activities. The greater survival of *C. d. dorsalis* within the Bay area, as compared to the Atlantic Coast, may be due to a historically lower level of human use of Bay beaches and to less natural mortality from winter storms, erosion, or other factors.

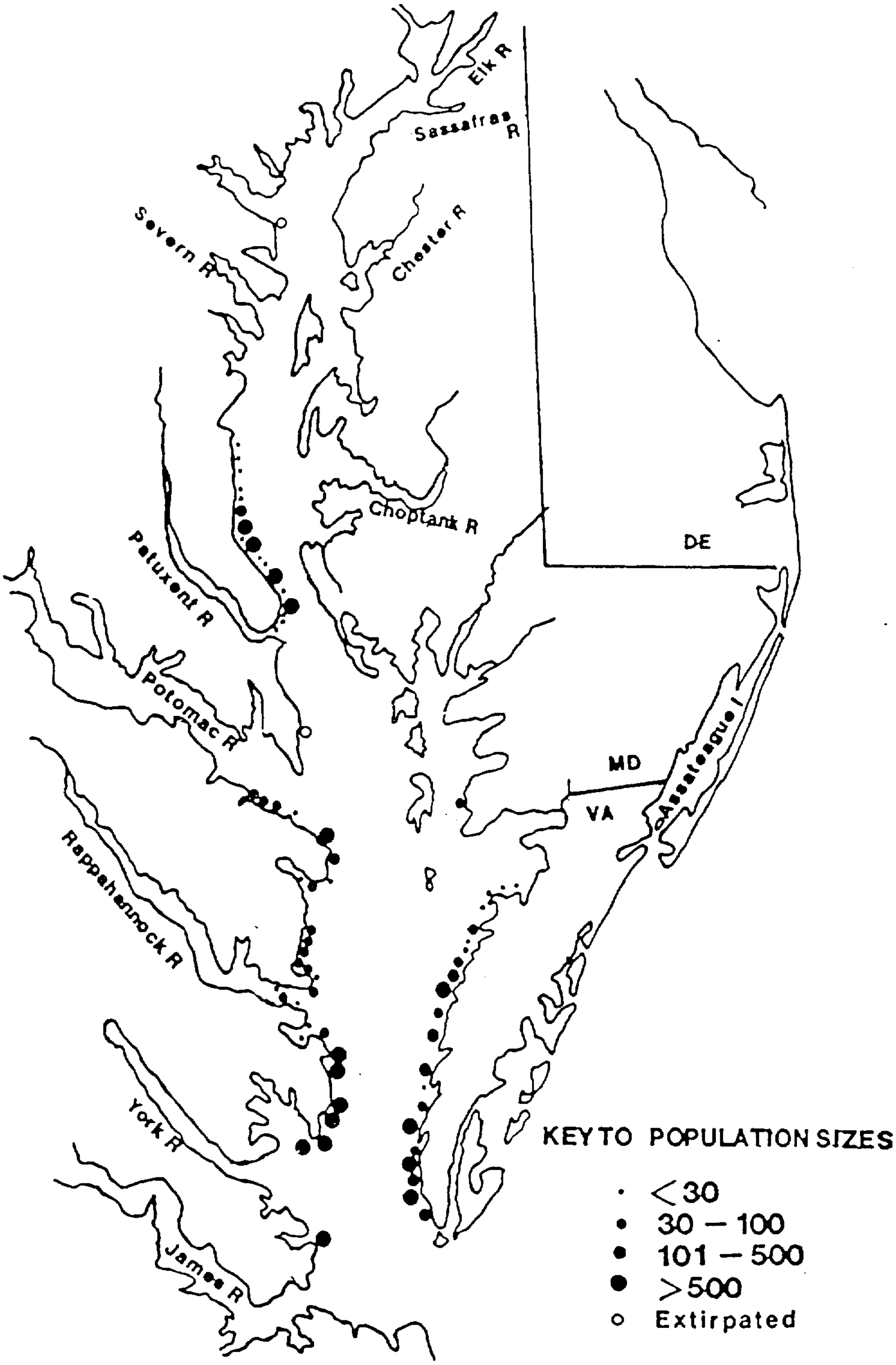

Figure 3. *Cicindela dorsalis dorsalis* sites in the Chesapeake Bay region

DESCRIPTION AND TAXONOMY

The northeastern beach tiger beetle, described as *Cicindela dorsalis* by Say (1817), has white to light tan elytra, often with fine dark lines, and a bronze-green head and thorax. It measures 13 to 15.5 mm (1/2 to 3/5 inch) in total length.

Cazier (1954) considered *C. dorsalis* and three other previously described species as subspecies (see page 2) of the single species *C. dorsalis*. Boyd and Rust (1982) confirmed that these four subspecies are clearly distinguishable. Morphological studies of taxonomic status comparing size and maculation of the four currently recognized subspecies of *Cicindela dorsalis* -- incorporating many more localities and larger sample sizes (over 1000 individuals) than were available to Boyd and Rust (1982) -- are in progress. Preliminary morphometric data indicate that a great deal of clinal variation exists within the entire complex. Especially notable is the latitudinal variation in maculation and size along the Atlantic coastline (B. Knisley unpubl. data).

Data also support the hypothesis that the subspecies *dorsalis* and *media* may be separate species. In addition to differing in size and elytral maculation (Figure 4), evidence from cross-taxon mating experiments indicates some degree of reproductive isolation between the two subspecies, although size-assortative mating also appears to be an important factor (Knisley *et al.* 1994). These two subspecies overlap in size (elytral length) in areas of present or former range overlap, but are completely or nearly completely separable when both size and maculation (darkness of elytral markings) are considered together (Knisley *et al.* 1994).

A recent study by Vogler *et al.* (1993) using polymerase chain reaction techniques to analyze levels of genetic variation in populations of *C. d. dorsalis* indicated that the isolated Martha's Vineyard population and Chesapeake Bay populations had very low genetic variability, possibly indicating a history of frequent natural extinctions. Three haplotypes were confined to the Martha's Vineyard population, and others were found throughout the Chesapeake Bay *C. d. dorsalis* populations, and, surprisingly, in some coastal *C. d. media* populations as well. The Martha's Vineyard population can be further distinguished by the presence of an allozyme allele (mannose phosphate isomerase) that has not been observed in the Chesapeake Bay beetles. Thus, although populations from these two areas represent the same subspecies, they should be considered as separate conservation units (Vogler and DeSalle 1994).

ECOLOGY AND LIFE HISTORY

Adult Behavior and Ecology

Much of what is known about the biology of *Cicindela dorsalis dorsalis* is included in Knisley (1987a) and in unpublished studies by Knisley and Hill (1989, 1990, 1992, 1993) and Hill and Knisley (1991). The following information is based primarily on these studies.

Northeastern beach tiger beetles are highly effective predators, using their long, sickle-like mandibles to capture and process their prey. Their primary food seems to be small amphipods, flies, or other beach arthropods. Adults have occasionally been observed scavenging on dead amphipods, crabs, and fish; much of their food may actually come from scavenging (B. Knisley and J. Hill pers. obs.).

In the Chesapeake Bay region, adult *C. d. dorsalis* emerge in mid-June, reach peak abundance by very early July, and begin to decline through August. *C. d. dorsalis* at Martha's Vineyard are about two weeks later in their schedule. The adults are active on warm, sunny days along the water's edge, where they are commonly seen feeding, mating, or basking (thermoregulation). The number of adult beetles active on rainy or cool, cloudy days is very low, probably because the beetles need to maintain high body temperatures for maximal predatory activity. Adults tend to be concentrated in wider sections of beach, and occur in smaller numbers or may even be absent from nearby areas of narrow beach. Mating and egg-laying occur from late June through August.

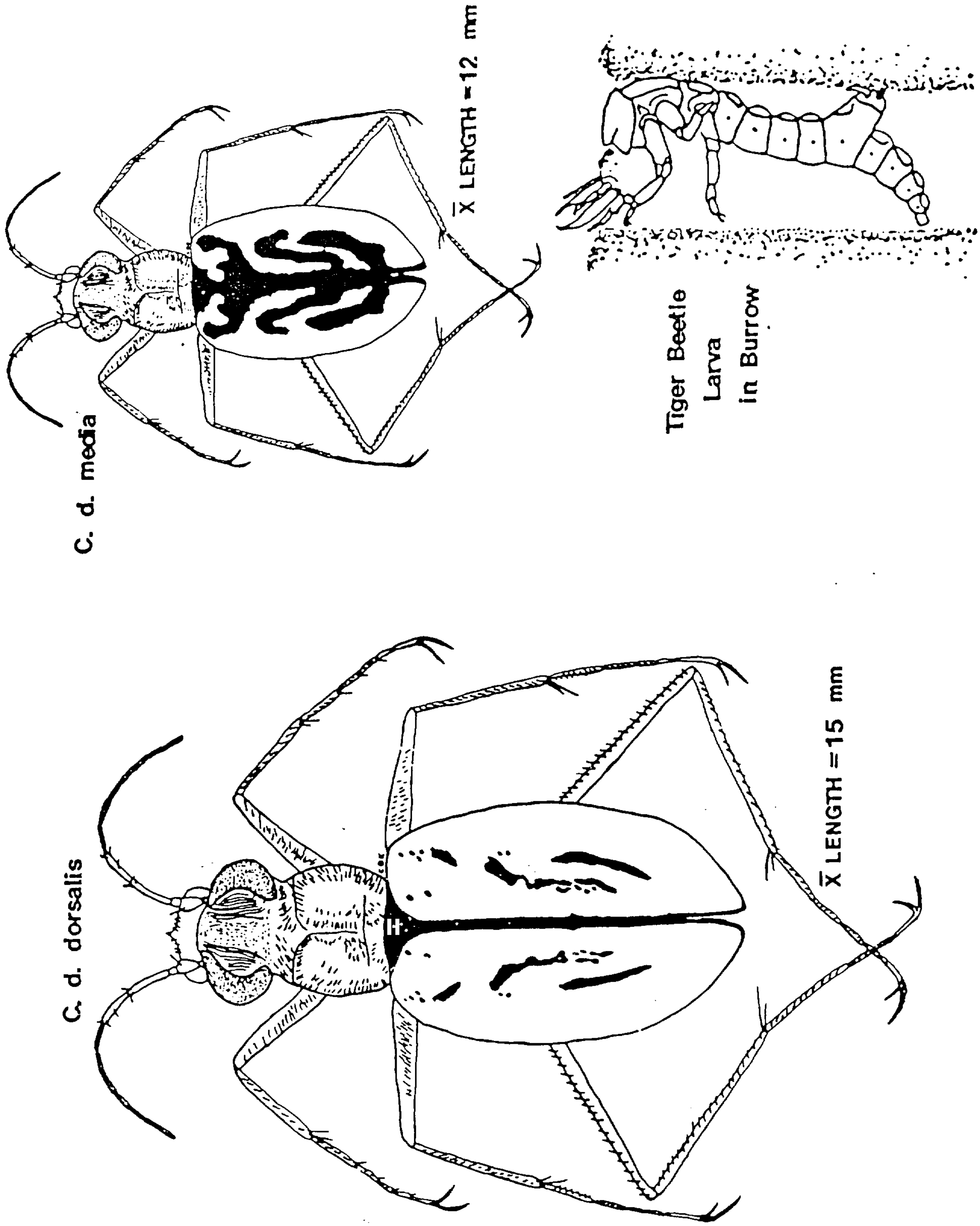

Figure 4. Comparison of *Cicindela dorsalis dorsalis* and *C. d. media*, and a typical larval tiger beetle in a burrow

On warm, calm evenings during peak summer activity in Maryland, well over 50% of the adult population seen during the day may also be nocturnally active. At Martha's Vineyard, a maximum of only about 25% of the adults have been observed at night, perhaps due to the cooler, windier weather, as compared with the Chesapeake Bay area (P. Nothnagle pers. comm.). Mating, feeding, and what seems to be a type of oviposition "nesting" behavior have been observed in Maryland at night. Regarding the latter behavior, females have been commonly found at night in shallow vertical burrows (5-8 cm deep), often with males guarding the burrow mouth. Since eggs have been recovered from some of these burrows, it seems that, at least on some occasions, egg-laying occurs in these burrows and at night (Knisley and Hill pers. obs.). If this is the case, this behavior is unique among tiger beetles, which typically oviposit by placing an egg just below the surface with the ovipositor while the female is positioned upright with the tip of the abdomen pressed into the ground. The location of these nests in the mid- to above-high tide drift zone, where larvae are also found, is additional evidence of *C. d. dorsalis* oviposition occurring in this way.

Larval Biology

C. d. dorsalis larvae are "sit-and-wait" predators; they dig vertical burrows in the sand and wait at the burrow mouth to capture small arthropod prey passing nearby (refer to Figure 4). Small amphipods appear to be the major food source for larvae. The larvae pass through three developmental stages or "instars". Burrow depth increases with stage -- first instar burrows typically average 10.0 cm (4 in), second instars 15.0-17.5 cm (6-7 in), and third instars 22.5-35.0 cm (9-14 in).

Larvae occur over a relatively narrow band (8-12 m) of the upper intertidal to high drift zone, but the zone may be wider in areas of washover or where the upper beach is flat and gets periodically wet from high tides. Many larvae are thus regularly covered during high tide. In response to the rising tide, they plug the burrow mouth with sand, then re-open when water levels drop; recent studies have shown that larvae can survive flooding for 3-6 days. While this intertidal location poses hazards of flooding and increased energy expenditure to maintain burrows, it is the zone where prey is most abundant. Larvae nearer to the water's edge tend to develop faster than those farther back where it is drier and prey items are less numerous (C.B. Knisley pers. obs.). Larvae have occasionally been found crawling on the beach, apparently moving to dig new burrows in a more favorable location. In contrast, the larvae of most other species of tiger beetles remain in the same burrow throughout their development. The burrow relocation behavior of *C. d. dorsalis* is likely a response to variations in tide levels, soil moisture, or sand accretion and erosion patterns. This behavior may allow larvae to select burrow sites with optimal physical conditions and/or greater abundance of food.

The degree of tidal flux and storm activity is much greater along Atlantic Coast beaches than within the Chesapeake Bay. The more dynamic coastal beaches, often exposed to direct ocean waves, change in profile and position annually in response to violent winter storms and summer wave conditions. On Martha's Vineyard, the larvae move 20-50 m up the beach to overwinter on higher ground (Nothnagle and Simmons 1990). This migration has apparently evolved as an adaptive behavior to avoid being washed out to sea during winter months.

Larvae are more difficult to study than adults because of their variable and somewhat unpredictable daily and seasonal activity patterns. The presence of active larvae is indicated by their open burrows in the sand. First instar larvae begin to appear in late July and August, after hatching from eggs laid by the adult cohort in June and July. Development progresses rapidly through the first stage; by September most of the larvae have reached the second instar. Activity continues well into November, when most larvae are second instars, but some have developed to the third instar. Third instars from the previous year's cohort also become active during the fall, apparently emerging from summer inactivity. Larvae of all instars, mostly second instars from the recent cohort and third instars from the previous year's cohort, overwinter on the beach, emerging from winter hibernation in mid-March. Most of the larvae from the new cohort will progress to and continue as third instars for an additional year, emerging the following June, nearly two full years after the eggs were laid. Some of the new cohort that hatched early and received an abundance of food may develop and emerge after one year. Third instar larvae of the previous year's cohort will emerge as adults in June. Thus, even and odd year cohorts constitute largely separate populations.

The daily period of larval activity is highly variable and much influenced by temperature, substrate moisture, tide levels, and season. The larvae, which lack a hard cuticle, are susceptible to desiccation and therefore tend to become inactive during hot, dry conditions. They may be active much of the day during cool or cloudy spring and fall days, except when covered by high tides. Times of maximal activity are early mornings after high tide before the sand dries and warms, and again in later afternoon after the tide has moistened and cooled the soil. During spring, numbers of active larvae are always lower than in the fall, as a consequence of winter mortality (A. Ringgold, Cape Cod National Seashore, *in litt*. 1993). During summer, very few active larvae, except those of the current cohort, can be found, even at night. Thus, summer may be a period of aestivation or inactivity for later instar larvae.

Natural Enemies and Limiting Factors

Although adult *C. d. dorsalis* seem to have few important natural enemies, asilid flies, birds, and spiders have been observed attacking them. Asilid flies capture tiger beetles while both are in flight; 13 of 15 asilid attacks observed by B. Knisley and J. Hill (pers. obs.) were unsuccessful. Asilids were much more successful in attacks of *C. hirticollis*, a slightly smaller species that co-occurs with *C. d. dorsalis*. Large size can provide some defense for tiger beetles against asilids (Shelly and Pearson 1978). On several occasions blue grosbeaks and common grackles were found eating *C. d. dorsalis* and *C. hirticollis* on the beach at Flag Pond, Maryland (Knisley and Hill pers. obs). Beach wolf spiders may be important nocturnal predators since they are quite abundant on the beach at night and have been seen feeding on adults several times (Knisley and Hill pers. obs.).

Larvae are probably more limited by natural enemies than are adults. Their main enemy is a small, ant-like parasitic wasp of the genus *Methocha*, which enters a burrow, paralyzes the larva with a sting and lays an egg on it. The egg hatches and the larval parasite consumes the tiger beetle larva as it develops. Observations and laboratory studies indicate that both second and third instars of *C. dorsalis* are suitable hosts; first instar larvae are apparently too small. *Methocha* are especially abundant and their effects greatest during the fall. Numbers of this parasite probably increase by passing through several generations while parasitizing *C. hirticollis* larvae, which are abundant on beaches during spring and summer.

At Martha's Vineyard, mites are commonly found on the ventral section of the thorax on third instar larvae, and occasionally on second instars. These mites may simply be "hitching a ride" on the larvae (a condition known as phoresy), but the exact nature of the association bears further investigation (P. Nothnagle pers. comm).

Larval mortality from erosion, winter storms, food limitation, and other natural factors is probably as high for *C. dorsalis* as it is for some other species of tiger beetles, many of which have only about 5% survival to the adult stage (Knisley 1987b).

Population Dynamics

Populations of *C. d. dorsalis* are highly variable from year to year; the beetle is subject to local population extinctions and capable of dispersal and recolonization (see, for example, Figure 5). Two- to three-fold or greater year-to-year variations in numbers are common in *C. d. dorsalis* (Knisley and Hill 1989, 1990; Hill and Knisley 1991). Populations discovered at Windmill Point in Maryland and at Hacks Neck in Virginia became extinct within a few years after they were found. Many sites that have adults, especially small numbers at small sites, are not suitable breeding sites, but may only temporarily support adults that have dispersed from other sites. The Drum Point, Maryland site was apparently colonized by adults in 1988 (23 counted). Numbers increased to 90 in 1989, decreased to 15 in 1990, then increased to 52 in 1994, with no larvae found. Larvae are not found or may not survive at many sites. This is probably the case at Accawmacke Plantation, Virginia (North Tract) where only a few early stage larvae were found, almost none of which survived (B. Knisley unpubl. data). New populations have become established at Scientists Cliffs and Parker Creek in Maryland and Smith Point in Virginia, where no *C. d. dorsalis* were found in earlier surveys.

Mark-recapture studies at Flag Pond in Maryland indicate that the beetles may have a regular dispersal phase during peak abundance in early July. Individual beetles have been recovered 8-19 km (5-12 mi) away from sites where they were marked. About one-third of the population at Flag Ponds in Maryland dispersed off-site during a two- to three-week period (Knisley and Hill 1989). It is probable that some individuals may disperse tens of miles, since adults in Maryland have been observed far from the nearest known population. For example, an adult was observed on Hart-Miller Island near Baltimore, Maryland in 1989, a distance of over 80 km from the nearest population in Calvert County (J. Stasz, Maryland National Capital Parks and Planning Commission, pers. comm.). Long-term survival of this species seems dependent upon a highly evolved ability to disperse for considerable distances, in order to colonize transient or well separated habitat.

REASONS FOR LISTING AND CONTINUING THREATS

The extirpation of *C. d. dorsalis* from most of its range has been attributed primarily to destruction and disturbance of natural beach habitat from shoreline developments, beach stabilization structures, and high recreational use (Hill and Knisley 1994), all of which may affect the larval stage (Knisley *et al.* 1987). Stamatov (1972) suggested that oil slicks, use of pesticides for mosquito control, increased vehicular traffic, and natural phenomena such as winter beach erosion, flood tides, and hurricanes have also contributed to the decline of this beetle. While each of these factors may have had some level of effect, especially when combined with high natural larval mortality, their relative importance is not known and specific evidence of their impact is limited.

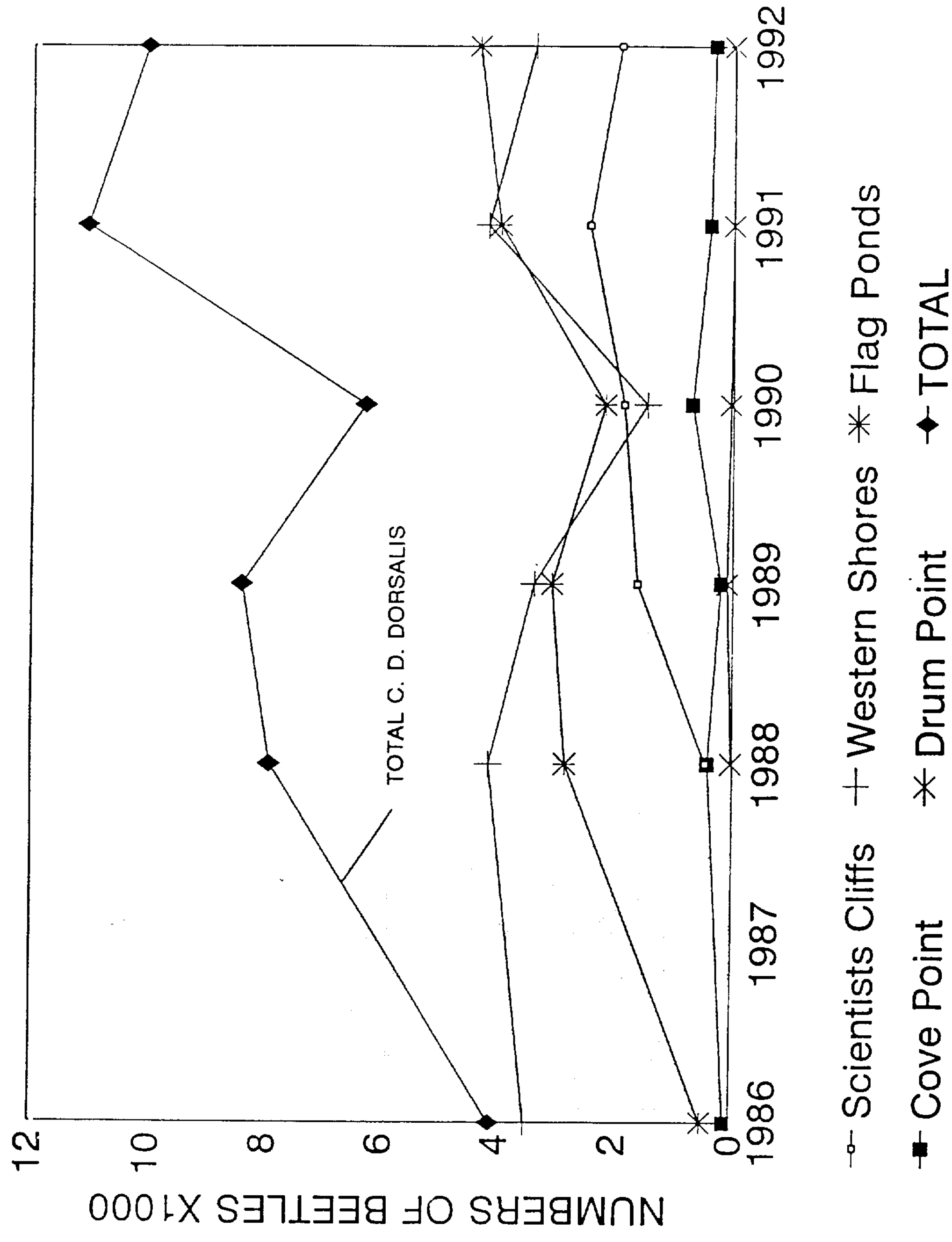

Figure 5. Numbers of *C. d. dorsalis* in Calvert County, Maryland, 1986-1992

Most of the major northeastern beach tiger beetle populations in Maryland, as well as many of Virginia's populations, are threatened by activities associated with human population increase. In Maryland, over 90% of the *C. d. dorsalis* population occurs in Calvert County, the most rapidly growing county in the State. All *C. d. dorsalis* sites are subject, to some degree, to oil spills and beach erosion. Threats to some of the more significant sites are summarized in Table 3.

Recent studies at Flag Ponds, Maryland, have provided specific evidence of negative impacts from various human activities (Knisley and Hill 1989, 1990; Hill and Knisley 1991). Flag Ponds, a recently developed county park, has experienced a dramatic increase in visitor use, from 2,000 to more than 20,000 per year over the past five years. The park has different areas of beach, which vary greatly in the amount of human use. Knisley and Hill found that the total numbers of larvae were significantly lower and percent survival of first and second instars much lower on the beach area where human activity was concentrated (heavy human use was defined as approximately 350 individuals per 800 m section of beach per week during summer). In contrast, larval recruitment and survival were much higher where visitor use was low. Experiments in which plots were trampled by the researchers several times, resulting in a 30% to 60% reduction of first and second instar larvae, substantiated the visitor use data. Negative effects of foot traffic apparently involve compaction or disruption of burrows or direct injury to larvae.

Although few beetles apparently completed development on the public use section, adults that emerged in other sections moved onto the public use beach. Adults occurred on all areas of the beach and their distribution was much less affected by human activity than that of larvae. However, their normal feeding and reproductive activity appeared to be adversely affected by human activity. For example, very few nests (see Adult Behavior) were found on the public beach at times when they were common on low use beach areas. It should be noted that management of the Flag Ponds county park is responsive to the need of retaining available habitat for the beetles, and the beach system is very dynamic, with sufficient turnover of habitat to accommodate a breeding population of the subspecies over the long term.

Table 3. Potential threats to selected Chesapeake Bay *C. d. dorsalis* populations.

MARYLAND	
Scientist Cliffs	Adjacent to private community. Subject to oil spills, erosion and recreational beach use.
Western Shores Estates	Adjacent to private community. Subject to oil spills, erosion, and recreational beach use.
Parker Creek	Private. Subject to oil spills and beach erosion.
Cove Point	Owned by private utility. Subject to oil spills, erosion, and *Phragmites* invasion of beach.
Flag Ponds	County Park. Subject to oil spills, beach erosion, heavy foot traffic, and shoreline control structures.
Janes Island	State owned. Subject to oil spills and beach erosion. Jetties proposed.
Cedar Island	State owned. Subject to oil spills and beach erosion. Jetties proposed.

VIRGINIA	(eastern shore of Bay heading south)
Silver Beach	Public campground. Subject to recreational use, oil spills and beach erosion.
Savage Neck	Private. Subject to oil spills and beach erosion.
Cape Charles South	Private. Large housing development proposed.
Picketts Harbor	Private. Subject to oil spills and beach erosion.

VIRGINIA	(western shore of Bay heading north)
Grandview	City park. Subject to oil spills and beach erosion. Some shoreline control under construction.
New Point	Private island. Subject to recreational use, oil spills and beach erosion.
Bavon Beach	Private. Subject to oil spills and beach erosion.
Winter Harbor	Private. Subject to oil spills and beach erosion. Possible COE beach nourishment project.
Bethel Beach	State-owned. Subject to oil spills and beach erosion.
Rigby Island	Private isolated spit. Subject to oil spills and beach erosion.
Sandy Point	Private isolated spit. Subject to oil spills and beach erosion.
Smith Point	Private. Subject to oil spills and beach erosion. Possible COE beach nourishment project.

Wilson (1970) and Nagano (1980) suggested negative impacts to tiger beetles from off-road vehicles. Schultz (1988) documented direct effects of ORV use on *Cicindela oregona* along stream edge habitat in Arizona. Vehicles may physically compact the beach substrate and/or disrupt thermal and moisture microhabitat gradients that are important for larvae (Schultz 1988). The best evidence of beach vehicle impacts to *C. dorsalis* comes from a survey on Assateague Island, Maryland (Knisley and Hill 1992). Adults and larvae of *C. d. media* were absent from a 16-km (10-mi) section of beach that receives heavy ORV use, but present on either side of the ORV zone, both on the north end of the island and to the south in the Virginia section. It is also significant that *C. d. media* was common on the northern portion of the ORV zone in 1973, but had disappeared by the summer of 1976, after ORV use became heavy (J. Glaser, Maryland Geological Survey, pers. comm.).

Surveys of *C. d. dorsalis* have also indicated an overall pattern of absence from beaches with moderate to heavy ORV use. The Martha's Vineyard site, one of two sites on the Atlantic Coast where the species has survived (Martha's Vineyard) is very inaccessible and has been well protected from visitor use and vehicle use for many years (T. Simmons, The Nature Conservancy, pers. comm). The newly discovered *C. d. dorsalis* site in Westport, Massachusetts is not used by ORVs, although it receives heavy pedestrian use (S. von Oettingen, U.S. Fish and Wildlife Service, pers. comm.).

Beach erosion, resulting from natural or anthropogenic beach modifications, may also have serious effects on *C. d. dorsalis* larval habitat. The northeastern beach tiger beetle typically is not found at sites that have only narrow, eroded beaches. At sites with large populations, few or no larvae are found in areas of narrow beach (1-3 m wide). Larvae seem to be limited to areas where beaches are at least 5 m wide, with some sand above the high tide zone. Adults are also less abundant in these narrow sections, although larvae are more sensitive to erosion and beach impacts than are adults.

Erosion at many sites within the Chesapeake Bay is a natural phenomenon resulting from rising sea levels and prevailing currents; this process has been exacerbated by beach development activities, which interfere with the natural beach dynamics (Ward *et al.* 1989). Beach stabilization structures such as groins, jetties, and bulkheads, which are designed to reduce erosion, may interrupt and capture sand from longshore movement and build up the beach around the structure, but rob sand from the down-drift shoreline.

There are many examples of erosion resulting from shoreline stabilization in the Chesapeake Bay (Ward *et al.* 1989). One such example is the north section of Flag Ponds, Maryland, where the beach has become severely eroded over the past 10 years since construction of the jetty at Long Beach just to the north (D. Williams, Calvert County Department of Parks, pers. comm). The eroding beach south of the ferry dock at Kiptopeke Beach, Virginia may be another example of this phenomenon. Natural points and spits may have the same effect as man-made features.

The effects of beach nourishment and stabilization on *C. d. dorsalis* are not known, and a study of erosion control structures is being conducted by C.B. Knisley to address several relevant issues. Although the addition of sand may actually maintain habitat in the long term, it is likely that its immediate effects would result in larval mortality. Larvae could be crushed, smothered, or unable to dig out and resume normal activity. Sand deposition could also have indirect negative effects on food (amphipod) availability. Deposition <u>may</u> have less impact if done in winter, when larvae are inactive and tidal action would erode some of the sand before larvae resume activity in the spring. The effects (both short- and long-term) of beach nourishment on the larvae need investigation. Since larvae seem to be very specific in their microhabitat distribution, sand particle size or other physical aspects of the microhabitat, e.g., slope or profile, may be critical.

CONSERVATION MEASURES

Research

Beginning in 1985, *Cicindela dorsalis dorsalis* has been studied by ecologists in Maryland, Virginia, and Massachusetts. Detailed knowledge of certain aspects of distribution, annual and seasonal abundance, and ecology has only recently been gained, and much remains to be learned. These activities have been funded by the U.S. Fish and Wildlife Service, The Nature Conservancy, and Natural Heritage Programs and associated State agencies in Maryland, Massachusetts, and Virginia.

From 1988 to 1991, detailed ecological studies were conducted at Flag Ponds Nature Park in Calvert County, Maryland and at Bethel Beach in Virginia to determine aspects of reproduction, feeding, predation and parasitism, dispersal, competition, habitat relationships, and general behavior. Studies by P. Nothnagle and T. Simmons in 1990 and 1991 focused on the New England population. The goal of these studies has been to provide information that will facilitate regional recovery.

Additional studies were conducted at Flag Ponds from 1988 to 1991 to determine the effects of human foot traffic on larvae. Repeated sampling along four beach areas of light to heavy foot traffic during three years of steadily increasing visitor use indicated that mortality of early instars increases in direct proportion to level of use (see page 17). Studies have also shown that larvae within exclosures suffer less mortality than do unfenced larvae in areas with high foot traffic.

Morphological studies comparing size and maculation of the four currently recognized subspecies of *Cicindela dorsalis* have been conducted. Tentative conclusions are discussed under Description and Taxonomy, as are the results of mate choice studies. In addition, results from a recent study of *C. dorsalis* mitochondrial DNA are available (Vogler *et al.* 1993).

Regulatory Protection

As a listed species, the northeastern beach tiger beetle receives some regulatory protection at both the state and Federal levels. The State of Maryland lists *Cicindela dorsalis* as endangered, thereby prohibiting collection or harassment of either subspecies (*dorsalis* or *media*). The Chesapeake Bay Critical Areas Law, regulations, and county Critical Area programs also provide certain levels of protection to the species. *Cicindela dorsalis* is on the endangered list in Massachusetts; the beetles and their habitat are further protected under the Massachusetts Wetlands Protection Act. Finally, regulations promulgated under the Federal Endangered Species Act prohibit collection or harassment of threatened animal species, and the Act protects species and their habitat from adverse impacts of any projects with Federal involvement.

Habitat Protection and Management

In Virginia, a conservation strategy has been prepared for *C. d. dorsalis* sites (Donoff *et al.* 1994). Twelve priority conservation sites for *C. d. dorsalis* in Virginia have been identified, conservation plans have been prepared for 11 of these sites, and Virginia NHP personnel are in the process of initiating a landowner contact program for 10 of the 12 sites. The primary factors considered in developing the conservation plans are: (1) the extent of occupied and potential habitat, (2) the maintenance of dynamic beach strand habitat, (3) provision for buffer lands, and (4) provision for species movement corridors.

The Virginia conservation strategy recommends treating several of the priority conservation sites as components of larger macrosites. The Bethel Beach Macrosite would include the following sites: Sandy Point Island, Rigby Island, Bethel Beach North, Bethel Beach, and Winter Harbor. Another macrosite is comprised of the Cape Charles, Picketts Harbor, and Kiptopeke State Park sites, plus three smaller sites (Elliotts Creek, Cape Charles-Old Plantation Creek, and Arlington-Old Plantation Creek). The metapopulation dynamics of *C. d.*

dorsalis at both these macrosites is very deserving of future field research (Donoff *et al.* 1994).

The Maryland Natural Heritage Program has also drawn protection area boundaries for important sites, and management activities, including restriction of access to these areas, have been initiated. Flag Ponds in Maryland was one of the first sites to be afforded special protection measures. Boundaries of the Natural Heritage Area (NHA) at Flag Pond surround a public beach area. The southern boundary was fenced off in 1989 by Baltimore Gas and Electric, who own a short section of beach to the south of the county park, at the urging of conservationists. This helped reduce foot traffic, trespass, and ORV problems. In 1991, the County Commission and Maryland Department of Natural Resources (DNR) implemented a formal closure of the NHA. The NHA boundary north of the public beach was fenced and posted to alert visitors that entry is only allowable for a four-hour period at low tide, and that pedestrian traffic can occur only along the edge of the water.

Other sites in both Maryland and Virginia are also receiving protection. At Cove Point in Maryland, the owner has initiated control of *Phragmites*, an aggressive grass that has been rapidly displacing open beach habitat in recent years. At Bethel Beach, Virginia, human impacts have been minimized on the sand spit, where *C. d. dorsalis* is concentrated, through fencing and patrols by local volunteers.

Similar control of access is being initiated at a few other sites in Maryland and Virginia. At Drum Point, Maryland, the landowners' association has entered into a cooperative agreement with the Maryland DNR to protect its small population and to control access. Landowner contact efforts have also been initiated in Maryland for the Parker Creek and Cove Point population sites. The owner of the Hack's Neck, Virginia site is interested in protection of *C. dorsalis* and has restricted access to this site. Finally, a management plan has been drawn up for the Accawmacke Plantation site, Cape Charles, Virginia (Knisley 1991).

Searches

From 1985 to 1992, searches were made for additional sites within the Chesapeake Bay and along much of the northeastern Atlantic Coast. Many previously unknown sites were found, especially in Virginia, by the Virginia NHP in 1989 and 1990 (Buhlmann and Pague 1992). In 1991 and 1992, two new Maryland sites were discovered in Tangier Sound, near Crisfield, by Maryland NHP biologists. While most Virginia and Maryland sites are now believed to have been identified, it is still possible that there are some additional sites. In New England, one population was discovered in the Westport, Massachusetts area in 1994, and there are a few remote islands that need to be checked or rechecked.

Reintroductions

An experimental reintroduction of *C. d. dorsalis* was conducted at two Chesapeake Bay sites during a five-week period in the summer of 1991 (Knisley and Hill 1991). The purpose of the trial reintroduction was to determine appropriate reintroduction methods, in preparation for conducting an operational reintroduction effort within historical range along the Atlantic Coast.

The techniques used to handle and release adult *C. d. dorsalis* on two sites in the Chesapeake Bay area (Kiptopeke South at the southern end of the Eastern Shore of Virginia, and Bayside Forest in Calvert County along Maryland's western shore) worked well, and there was no evidence of unusual or different behavior of introduced beetles at the transplant sites, even though the sites used were not considered to be ideal beetle habitat. The major cause for concern in conducting future reintroduction lay in the low recovery (capture) rates of introduced beetles.

Overall, 79 males and 43 females were recovered from a combined total of 750 adult beetles released at the two sites (Knisley and Hill 1991). Whether this moderate recovery rate (16.3%) was due to dispersal or mortality of the remaining individuals is unknown. However, given the lack of other alternatives for restoring the northeastern beach tiger beetle along the Atlantic Coast, the study concludes that reintroduction of beetles from the Martha's Vineyard population into suitable, historical habitat along the Atlantic Coast is worthy of strong consideration, as long as donor population levels are adequate.

During the summer of 1992, adult numbers of *C. d. dorsalis* at Martha's Vineyard (over 900) appeared adequate to attempt a preliminary reintroduction. In July, 70 newly eclosed beetles (35 ♂♂ and 35 ♀♀) from this population were transferred to Cape Cod National Seashore, using recommended protocol (see Recovery Task 9.2). Unfortunately, the weather turned cold and cloudy during the release. The day following the release, only 18 beetles were observed. The next day, there were 10, and the number declined thereafter, with the result that this reintroduction attempt was judged unsuccessful. Nevertheless, some information was gained from this attempt. For example, the beetles were observed to move only short distances from the release site. This and other observations have led P. Nothnagle (pers. comm.) to hypothesize that non-dispersing adult beetles have very limited ranges. This behavior, if substantiated, would have significant implications for management of both natural and re-established populations. Based on the results of both of these attempted re-introductions, it should be worth investigating whether the release of larvae, rather than adult beetles, will be more successful.

J.M. Hill and C.B. Knisley recently prepared a report for the U.S. Fish and Wildlife Service (Hill and Knisley 1994) on the results of surveys for *C. d. dorsalis* and *C. d. media* at historical sites in New Jersey. They confirmed the lack of current *C. d. dorsalis* sites, but identified three historic sites for this taxon that could serve as reintroduction sites, as follows: (1) Gateway National Recreation Area, which has low pedestrian use at the northern tip, moderate off-road vehicle use, and an adequate prey base; (2) Island Beach State Park, which has a Northern Natural Area with similar characteristics but appeared to be slightly less suitable because of more ORV use, an apparently lesser prey base, and no indication of a more tolerant tiger beetle, *C. hirticollis*, which was found at Gateway NWR; and (3) Forsythe National Wildlife Refuge, at the Holgate peninsula, even though it has heavy ORV use except during late spring and summer, when nesting plovers and terns are present. This latter site would be excellent if ORV use was stopped.

With the support of the National Park Service, a project is underway (fall of 1994) to introduce 850 *C. d. dorsalis* larvae on Sandy Hook, Gateway National Recreation Area. This project involves collection of first, second, and third instar larvae from three large source populations in Virginia. These larvae will then be taken to the release site the day after collection and released over the following two days. The protocol for this reintroduction contains provisions for monitoring through summer of 1996 to determine if a new population has become established (Hill and Knisley 1994).

RECOVERY STRATEGY

Recovery for the northeastern beach tiger beetle will depend to a large extent on re-establishing the species across its former range along the Atlantic Coast and protecting it within the Chesapeake Bay region. The best approach for achieving this is through landscape scale conservation. This recovery plan thus defines several Geographic Recovery Areas (GRAs) for conserving *C. d. dorsalis* and its ecosystem, providing a framework within which protection and population establishment efforts can be ranked and implemented. Recovery will hinge on maintaining the ecological integrity of essential tiger beetle habitat within each GRA, in order to achieve the population levels and structure needed for this species.

Additional tiger beetle populations that are established along the Atlantic Coast will be considered as essential for meeting recovery objectives. However, the only available habitat for establishment of such populations is on protected beaches in areas where recreational use is limited and vehicles are not driven on the beach. Given the ever-increasing human use of Atlantic Coast beaches, it stands to reason that any protected beach where the beetles are reintroduced will be in proximity to heavily used recreational beaches. It follows that during and after the re-establishment process, there will be movement of beetles from protected beaches to public use beaches, resulting in some incidental take. The U.S. Fish and Wildlife Service recognizes the possibility of this incidental take as an unavoidable cost of achieving recovery goals for *C. d. dorsalis*, and is committed to resolving incidental take issues that arise from reintroduction efforts as fairly and expeditiously as possible, primarily through the Section 7 process.

Integral benefits to all parts of the ecosystem should ensue from protection and restoration of tiger beetle habitat, including recovery benefits to the piping plover and seabeach amaranth. Habitat management concern for other taxa will thus be a critical aspect of *C. d. dorsalis* recovery efforts.

Nine GRAs have been identified to structure recovery efforts, as follows:

GRA 1- Coastal Massachusetts and Islands
GRA 2- Rhode Island, Block Island, and Long Island Sound
GRA 3- Long Island
GRA 4- Sandy Hook to Little Egg Inlet, NJ
GRA 5- Calvert County, MD
GRA 6- Tangier Sound, MD
GRA 7- Eastern Shore of Chesapeake Bay, VA
GRA 8- Western Shore of Chesapeake Bay (north of Rappahannock River), VA
GRA 9- Western Shore of Chesapeake Bay (south of Rappahannock River), VA

Full recovery will require the establishment of populations in each of the four Atlantic Coast GRAs as well as protection of existing populations in each of the five Bay GRAs.

PART II: RECOVERY

RECOVERY OBJECTIVE

The objective of the *Cicindela dorsalis dorsalis* recovery program is to restore this species to a secure status within its historical range, thereby enabling its removal from the Federal list of endangered and threatened wildlife and plants. Delisting will be considered when:

1. At least three populations have been established[1] and permanently protected[2] within each of the four designated Geographic Recovery Areas covering the historical range of the subspecies in the Northeast, with each GRA having one or more sites with large populations (peak count $\geq$ 500 adults) and sufficient protected habitat for expansion and genetic interchange.

2. At least 26 populations are permanently protected at extant sites distributed among the five Chesapeake Bay GRAs as follows:

   Calvert County, MD -- four largest populations
   Tangier Sound, MD -- two large ($\geq$ 500 adults) populations
   Eastern Shore of Chesapeake Bay, VA -- four large populations, four others
   Western Shore of Chesapeake Bay (Rappahannock River north), VA -- three large populations, three others
   Western Shore of Chesapeake Bay (Rappahannock River south), VA -- three large populations, three others

3. Life history parameters (including population genetics and taxonomy), human impacts, and factors causing decline are understood well enough to provide needed protection and management.

4. There exists an established, long-term management program in all states where the species occurs or is reintroduced.

1 "Established" is defined as self-maintaining for at least five years, with no foreseeable threats.

2 "Permanently protected" is defined as long-range protection from present and foreseeable anthropogenic and natural events that may interfere with their survival. Adequate protection measures include land acquisition, conservation agreements and/or easements, and management measures to protect the species' habitat; this includes accounting for off-site impacts such as littoral sand drift.

RECOVERY TASKS

1. Maintain a recovery group and an *ad hoc* task force.
   A recovery group (comprising biologists, land use planners and managers, and educators) will be responsible for coordinating and involving stakeholders in implementation of the recovery program. This group will meet on an annual basis. Among the group's first tasks will be to continue monitoring certain sites and to identify potential reintroduction sites.

   An *ad hoc* task force, to include non-governmental members of the recovery group, will periodically attend field meetings to offer scientific advice on matters related to recovery goals.

2. Monitor existing populations.
   Regular monitoring will provide an indication of population fluctuations and allow detection of population changes over time in relation to habitat changes or other impacts. Monitoring will show the relationship between habitat size, habitat quality, and population size and stability.

   2.1 Monitor adult beetles. In general, sites should be prioritized for monitoring by GRAs. The Massachusetts populations should be visited two to three times each year, to cover the time of peak adult numbers. In the Chesapeake Bay area, priority sites should be surveyed for adults and larvae in peak season (July) over a period of several years. In both areas, a total count of adults (or, where numbers are high, as accurate an estimate as possible) should be made.

   The purpose of these counts will be to assess annual fluctuation in population size in both large and small populations, and to determine if management is needed to maintain or increase population size. It is anticipated that after approximately six consecutive years of counts, if conditions warrant, a less frequent, e.g., triennial, monitoring schedule may be adopted. Additional monitoring as part of a research design to answer specific questions should also be implemented.

2.2 Monitor larvae. Surveys for larvae should be conducted in peak larval season (September) at a minimum of three large and three small sites in the Chesapeake Bay region, and at the Massachusetts sites. These surveys should be conducted over a period of at least two to three years. Larvae will be counted on one- or two-meter wide (or wider) transects at random intervals. Conducting larval counts over successive years should help improve the predictive capabilities for adult populations as well as provide a comparison of recruitment in large and small populations.

3. Determine population and habitat viability.
While information regarding population viability and habitat requirements will be critical for long-term acquisition, reintroduction, and preservation efforts, current gaps in quantified data should not deter initial recovery efforts.

3.1 Analyze population viability. A preliminary estimate of 500-1000 adults as a minimum viable population size for *C. d. dorsalis* (Knisley and Hill 1990) is based on estimates in the literature (Mettler and Gregg 1969, Lacy 1987, Thomas 1990) and on preliminary observations of population stability and decline at several sites. However, at present no long-term genetic or demographic information is available to accurately model how many adults on how large an area, and in what proximity to other large or small populations, are needed to sustain long-term population viability.

Critical population size will be determined by annual monitoring of small populations (Task 2) to ascertain the size at which a population becomes unstable. Monitoring of those populations with 50 to 500 adults over a three-year period will be necessary for this task. Population viability analysis will be conducted by comparing population size, trends, and genetic variability with habitat availability, quality, and isolation (Murphy *et al.* 1990).

3.2 Model effects of habitat changes. A predictive model of shoreline/habitat changes relative to population performance is needed. This will involve determining whether changes in shoreline configuration or other habitat features at individual sites are associated with corresponding changes in tiger beetle population levels at these sites. Several years of beetle population data will be required to control for year-to-year fluctuations associated with local weather conditions. Data on shoreline land use changes in Calvert County are currently being gathered and assembled into a GIS database. Similar data should be eventually collected throughout the species' range.

4. Identify and protect viable populations and their habitat. Initially, protection efforts should concentrate on sites with high defensibility. In addition to the Massachusetts sites, Atlantic Coast sites that are determined to have potential for reintroduction will need protection in preparation for reintroduction efforts. These will include the areas identified by Hill and Knisley (1994) in New Jersey, as well as:

    Other Martha's Vineyard and Cape Cod sites, including
        Coast Guard Beach, Eastham
    Watch Hill, Rhode Island
    Block Island in Rhode Island
    Other sites as identified in GRAs 1, 2, and 3

Several sites in the Chesapeake Bay region merit protection. Priority sites in Virginia are listed under Conservation Measures. Priority sites in Maryland include:

Calvert County:

    Western Shores
    Flag Ponds
    Drum Point
    Scientists Cliffs
    Cove Point
    Parker Creek

Tangier Sound:

Cedar Island
Janes Island

These sites and others should also be evaluated in terms of other wild beach elements that they may contain, and this information should be factored into selection of sites for protection.

4.1 Pursue long-term protection of priority sites. Acquisition, leases, easements, and management agreements will be considered as means to protect northeastern beach tiger beetle habitat. County officials will be urged to initiate long-range land use planning that will ensure protection of *C. d. dorsalis* sites in perpetuity.

4.2 Initiate landowner contacts for all known populations. Landowners, caretakers, or managers of all sites with existing populations (regardless of their protection priority) are being notified by representatives from state Natural Heritage Programs about the existence of *C. d. dorsalis* on their property. An effort should be made during each contact to provide the landowner with information pertaining to the species and to elicit support for the recovery effort. As appropriate, permission should be sought to monitor, study, and manage the species over the long term. The landowner should be informed about any pertinent Federal, state, or local laws regarding protection of listed species.

4.3 Use existing laws and regulations to protect the beetles and their habitat. State and Federal laws prohibiting take and Federal activities that would jeopardize the species' continued existence will be fully implemented in order to maximize protection of populations.

5. Study life history parameters.
This information is essential to the management and recovery of *C. d. dorsalis*. Workers in the New England and Chesapeake Bay areas should communicate frequently and coordinate efforts (see Task 1).

5.1 Determine limiting factors. Although much information on limiting factors has recently been acquired, additional research is needed to better understand the beetle's life history and to refine management techniques. In particular, the following factors need study: (a) habitat factors that affect larval distribution, (b) the contribution of winter storms and other factors to larval mortality, (c) seasonal movements of larvae, (d) overall importance of adult predation and larval parasitism, (e) the importance of competitive and other interactions with sympatric congeners (for example, does the presence of large numbers of *C. hirticollis* increase parasitism by *Methocha* or in any other way decrease survival of *C. d. dorsalis*?), and (f) reproductive output per female. Comparative studies in New England and the Chesapeake Bay should be continued, since the limiting factors for these two stocks may be very different. Although reproductive compatibility between subspecies has been investigated and some electrophoretic work has been conducted, further reproductive studies are planned.

5.2 Determine dispersal distance and sex ratio. A knowledge of dispersal capabilities is important, because survival of this species seems to depend on colonization of transient habitats. Knowledge of dispersal abilities will aid in the selection of reintroduction sites, will be useful in the refinement of GRA boundaries, and could aid in refining reintroduction techniques. In studies to date, dispersal appears to be mostly by males; if so, males may be the sole transfer route of genetic material between populations. This could have genetic consequences that should be considered in management and reintroduction efforts. For example, the male:female ratio of founding populations might be adjusted to account for male dispersal. A study of the percentage and the average and maximum distance of dispersal would require marking several thousand beetles at large population sites (e.g., in Maryland, the Western Shores, Flag Ponds, and Cove Point sites) during the week before dispersal flights, then capturing and sexing marked individuals at other coastal sites during the month after dispersal.

5.3 <u>Complete taxonomic studies</u>. A better understanding of the taxonomy of *Cicindela dorsalis* will aid in the management and recovery of this listed subspecies. The proper source of adults for reintroduction is one of the practical benefits that a more complete knowledge of taxonomy will provide. Early results of mitochondrial DNA analyses indicate that Chesapeake Bay *C. d. dorsalis* differ considerably from the Martha's Vineyard (MVi) *dorsalis* population. Bay *dorsalis* appear to be fixed for a single haplotype, while a different haplotype predominates at MVi. Somewhat surprisingly, the MVi population was found to be more variable, with a total of four different haplotypes. Bay and MVi *dorsalis* were found to be about equally distinct from *C. d. media* (Vogler *et al.* in press). Morphometric studies and mate choice experiments of these taxa also need to be completed; this work is being continued in 1993.

6. <u>Evaluate human impacts</u>.

6.1 <u>Complete human impact studies</u>. Human activity appears to be the single most important factor in the loss or reduction of populations of *C. d. dorsalis*. Off-road vehicle and foot-traffic perturbation trials should be completed on six more study plots at Flag Ponds or Western Shores.

6.2 <u>Study effects of shoreline alteration</u>. Studies that examine short- and long-term effects of shoreline control structures and beach nourishment operations should be conducted. Such studies, particularly the beach nourishment project, will be performed in close cooperation with the U.S. Army Corps of Engineers, most likely in conjunction with operational beach nourishment activities.

7. Implement appropriate management measures at natural population sites.

Based on results of studies described in Tasks 3 and 4, management actions will be implemented as necessary or appropriate. For example, it may become necessary to restrict human foot traffic from sites, or to manipulate vegetation. Management activities will be conducted only where landowner and community support exists.

8. Search for additional populations in the Chesapeake Bay region.

Searches will be conducted in areas where additional sites may exist. While most Virginia and Maryland sites are now believed to have been identified, it is still possible that there are some additional sites, and given the shifting nature of the habitat in the Bay and elsewhere, new sites may form and some current sites may relocate or even disappear. Specific areas to check are the vicinity of the Maryland-Virginia boundary on the Eastern Shore and also in remote areas of the western shore of Virginia between the Rappahannock and Potomac Rivers. In New England, there are a few sites that need to be checked or rechecked, such as Gardiners Island and other remote islands; however, extensive survey work in New England over the past several years has failed to locate any populations other than the one remaining site at Martha's Vineyard.

Documentation should be provided for each site checked in the field, since even unoccupied sites could become colonized later by natural dispersal. In addition, some unoccupied sites might provide ideal reintroduction sites.

9. As appropriate, reintroduce populations to sites within *C. d. dorsalis*' historical range.

Based on preliminary genetic and mating study results, priority will be given to reintroducing transplant stock of regional origin. Only stock from the two sites in Massachusetts should be reintroduced to sites along the Atlantic Coast, unless (a) further genetic studies show that populations from the two regions are genetically very similar (as defined by the geneticists), or (b) the only known remaining natural populations in New England disappear. The Massachusetts populations must be sufficiently large to sustain the loss of the translocated beetles, with a maximum of 8% of the adults from these source populations being translocated to other sites during any one year.

Taking recognized genetic differences into account, and recognizing that Bay beetles are not as well adapted to Atlantic Coast conditions as is the coastal stock (for instance, larval behavior is different between the two stocks, with coastal larvae migrating up-beach and Bay larvae lacking this behavior), it may eventually prove necessary to consider mixing the two stocks to achieve recovery objectives. Genetic consequences and reproductive compatibility will be factored into any determinations about the advisability or inadvisability of pursuing this course of action.

9.1 Determine, obtain access to, and prepare appropriate reintroduction sites. Near-term reintroduction efforts should focus on the Atlantic Coast GRAs. Museum specimens have been useful in identifying the historical range of *C. d. dorsalis*; however, it appears that few of the historical sites in the Northeast are currently suitable for reintroduction efforts. Additional sites will need to be checked and possibly restored before adult beetles are released. In some cases this process may require negotiation with the landowner as well as fencing, removal of shoreline control structures, etc., as deemed necessary for successful population establishment. When possible, preference will be given to sites on public land and sites with other rare or listed organisms. Ideally, sites should include an adequate area for dispersal of the founder population within the site, and other dispersal areas should be available nearby. Technical assistance will be provided to New England personnel involved in reintroduction efforts.

9.2 Design and test reintroduction protocol. When possible, releases should be made soon after elytra have hardened, i.e., mid-July, although releases as late as September may be considered. An equal sex ratio is preferable. Adult beetles should be collected, placed individually in vials, chilled on ice, rushed to the reintroduction site, released in small groups, and watched until they have regained mobility. Because preliminary data indicate that a large percentage of introduced northeastern beach tiger beetles die or disperse from the introduction site (Knisley and Hill 1991), efforts should be made to increase site fidelity or decrease mortality of introduced individuals. Releases should, at a minimum, be implemented over two successive years at each release site, in order to allow for an annual adult emergence. When additional *C. d. dorsalis* populations are established, appropriate management will be implemented as described in Task 5.

9.3 Conduct reintroductions on an operational basis. As described above, an experimental reintroduction was attempted in New England in 1992. One to three reintroductions to new sites or augmentations of founder populations should be attempted each year until recovery conditions are met, contingent on available parental stock and readiness of new sites. If the initial reintroductions using stock from the Martha's Vineyard population fail after 3-4 years, trial introductions of Chesapeake Bay stock to the Atlantic Coast may then be considered. A reintroduction will be considered a success if adult reproduction results in two successful cohorts, i.e., larvae emerge as adults in two successive years, ideally beginning two years after the first reintroduction at the site.

10. Implement educational activities for landowners and the public at large.

Landowners with populations of *C. d. dorsalis* should be contacted by knowledgeable conservation professionals and informed about management for the beetle, and educated about the value and protection needs of endangered species in general and *C. d. dorsalis* in particular. This effort is already underway in Maryland (Maryland Natural Heritage Program 1992).

In addition, the public at large should be educated about endangered species in order to engender broad public support for recovery activities. Many people may be unfamiliar, initially, with the concept of an endangered insect. Educational brochures, posters, slide shows, films, etc., should be prepared for widespread distribution. This effort has also been initiated in Maryland. Publication of scientific papers and general interest articles in non-technical publications by those involved in research and recovery should also be encouraged. Educating the public about rare tiger beetles should further the cause of endangered species conservation in general.

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PART III: IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the recovery program over the next three years. It is a guide for meeting the recovery objectives discussed in Part II of this plan. This schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. The schedule will be updated as recovery tasks are accomplished.

Key to Implementation Schedule Priorities (column 1)

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Key to Responsible Agencies (column 5)

USFWS	--	U.S. Fish and Wildlife Service
R5	--	USFWS Region 5 (New England to Virginia)
ES	--	Ecological Services (includes Endangered Species)
SMA	--	State management agency
Priv	--	Private individual or organization
TNC	--	The Nature Conservancy

IMPLEMENTATION SCHEDULE

Northeastern Beach Tiger Beetle Recovery Plan

September 1994

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Est. Costs ($1000) FY1	FY2	FY3	Comments
1	Monitor adult beetles.	2.1	Ongoing	R5/ES	SMA, Priv	15.0	15.0	15.0	+ 10K/yr for 8 years.
1	Pursue long-term protection of priority sites.	4.1	5 years	R5/ES	SMA, TNC	11.0	8.5	8.5	+ 8.5K/yr for 2 years. Does not include full site acquisition costs.
1	Initiate landowner contacts for all known populations.	4.2	3 years	R5/ES	SMA, TNC	6.0	3.0	3.0	
1	Use existing laws and regulations to protect the beetles and their habitat.	4.3	Ongoing	R5/ES	SMA	1.0	1.0	1.0	+ 1,000/yr for 8 years.
1	Design and test reintroduction protocol.	9.2	3 years	R5/ES	SMA, Priv	4.5	4.5	3.0	
2	Maintain a recovery group and an *ad hoc* task force.	1.	Ongoing	R5/ES	SMA, Priv	1.0	1.0	1.0	+ 1,000/yr for 8 years.
2	Monitor larvae.	2.2	3 years	R5/ES	SMA, Priv	5.0	5.0	5.0	
2	Determine dispersal distance and sex ratio.	5.2	3 Years	R5/ES	SMA, Priv	5.0	5.0	5.0	
2	Complete taxonomic studies.	5.3	2 years	R5/ES	SMA/Pri	10.0	4.0		
2	Complete human impact studies.	6.1	1 year	R5/ES	SMA, Priv	2.5	2.5		
2	Study effects of shoreline alteration.	6.2	3 years	R5/ES	COE, SMA, Priv			10.5	+ 5K/yr for 2 years. Beach nourishment study would coincide with operational Corps activity.

Northeastern Beach Tiger Beetle Recovery Plan, Implementation Schedule (continued), September 1994

Priority	Task Description	Task Number	Duration	Responsible Agency USFWS	Responsible Agency Other	Est. Costs ($1000) FY1	FY2	FY3	Comments
2	Implement appropriate management measures at natural population sites.	7.	8 years	R5/ES	SMA				Will be initiated in FY4 at a cost of 10K for 8 years.
2	Determine, obtain access to, and prepare appropriate reintroduction sites.	9.1	3 years	R5/ES	SMA, TNC	2.0	2.0	2.0	
2	Conduct reintroductions on an operational basis.	9.3	10+ years	R5/ES	SMA/Pri			3.5	+ 3.5K/yr for 8 years.
3	Determine minimum viable population size and perform a population viability analysis for sites.	3.	1 year	R5/ES	SMA/Priv	4.0			
	Determine limiting factors.	5.1	3 years	R5/ES	SMA/Priv	10.0	10.0	10.0	
3	Complete taxonomic studies.	5.3	2 years	R5/ES	SMA/Priv	4.0	4.0		
3	Search for additional populations in the Chesapeake Bay region.	8.	2 years	R5/ES	SMA/Priv	2.0	2.0		
3	Implement educational activities for landowners and the public at large.	10.	Ongoing	R5/ES	SMA	4.0	2.5	1.5	+ 1.5K/yr for 8 years.

LIST OF REVIEWERS

The following individuals and agencies submitted comments during technical/agency review of the draft Northeastern Beach Tiger Beetle Recovery Plan. The comments have been incorporated as appropriate into this plan. All comments are on file in the Chesapeake Bay Field Office of the U.S. Fish and Wildlife Service, and are available for review upon request.

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